Sheep & Goat Research Journal
Volume 20, 2005

Feedlot Performance and Carcass Characteristics of Lambs Sired by Texel, Romanov, St. Croix or Dorset Rams from Polypay and St. Croix Ewes

W.A. Phillips[1,2], M.A. Brown[1], H.G. Dolezal[3,4] and G.Q. Fitch[3]

[1] USDA-ARS Grazinglands Research Laboratory, El Reno, OK 73036
[3] Animal Science Department, Oklahoma State University, Stillwater, OK 74074.
[4] Present address Excel Corp. P.O. Box 2519 Wichita, KS 67201

[2] Corresponding Author:
W.A. Phillips, bill.phillips@ars.usda.gov or (405) 262-5291

Summary

Over a 2-year period, crossbred lambs resulting from the mating of Texel (T), Romanov (R), and St. Croix (S) rams with Polypay (P) and S ewes, were finished during the summer and late fall to determine feedlot performance and carcass characteristics. A total of 175 wether lambs of the five genotypes (R x P, R x S, S x S, T x P and T x S) were fed a high-energy diet for an average of 110 d (Experiment 1). Purebred St. Croix lambs weighed less ($P < 0.05$) at the beginning and end of the finishing period, had the lowest average daily gain (ADG) ($P < 0.05$), and the lowest Gain:Feed ($P < 0.10$) of the five genotypes evaluated. All five genotypes produced carcasses with a quality grade ≥ Choice. In a subsequent 2-year experiment (Experiment 2), 251 lambs sired by either Dorset or St. Croix rams from the ewes created in Exp.1 were used. Dorset-sired lambs were heavier ($P < 0.10$) at the end of the feeding period and had greater ADG ($P < 0.10$) than lambs sired by St. Croix rams. Wether lambs were heavier ($P < 0.10$), grew faster ($P < 0.10$) and ate more ($P<0.05$) feed than female lambs. Lambs from crossbred ewes were heavier ($P <0.05$) at the beginning and end of the finishing period and grew faster ($P < 0.10$) than lambs from purebred St. Croix ewes. When Dorset rams were used as the terminal sire, lamb feedlot performance was similar among the five ewe genotypes used in this study.

Key words: Lambs, Crossbreeding, Feedlot, Carcass Quality, Carcass Cutability.

Introduction

Per capita lamb consumption has steadily declined over the past three decades due to changes in eating habits of U.S. consumers and a widening gap between the retail prices of lamb meat in comparison with other meat choices, particularly beef (Schroeder et al., 2001). To be more competitive, retail lamb prices must be lowered, which means lowering lamb production cost either by increasing lamb productivity per ewe or decreasing the cost of production inputs (Lewis et al., 1996). Crossbreeding programs can be used to exploit differences in breeds, to increase heterosis and to match genetic and environmental resources for the most efficient production (Freking et al., 2000; Leymaster and Jenkins, 1993). Texel sheep were imported into the United States for evaluation as a new terminal sire breed. Leymaster and Jenkins (1993) reported that Texel-sired lambs produce carcass that were leaner, distributed fat differently and had a different carcass shape than Suffolk-sired lambs.

Hair sheep breeds have been considered in the past for crossbreeding programs with wool sheep breeds (Burke and Miller, 2004; Notter et al., 2000 and 2003). Bunch et al. (2004) reported that overall sensory acceptance ratings were higher for purebred St. Croix lambs than for lambs from wool breeds. They concluded that hair sheep could be used in a cross-breeding program to improve meat palatability. During the development of crossbred females, crossbred males are also produced. The majority of these males do not go into breeding programs but are placed in feedlots for finishing. The objectives of the experiments reported in this paper were 1) to compare the feedlot performance and carcass characteristics of purebred St. Croix lambs to lambs containing 50 percent St. Croix breeding (Experiment 1), and 2) to compare the feedlot performance and carcass characteristics of lambs sired by Dorset or St. Croix rams from purebred St Croix or crossbred ewes (Experiment 2).

Materials and Methods

Experiment 1:

A total of 175 wether lambs were used to determine feedlot performance and carcass characteristics of spring born lambs sired by St. Croix (S), Romanov (R) or Texel (T) rams from either St. Croix or Polypay (P) ewes. Lambs of RxP, RxS, SxS, TxP, TxS genotypes (genotypes refer to both purebred and crossbred lambs) were born in the spring of 1993 (Year 1; n=72) and 1994 (Year 2; n=103) and reared at the USDA-ARS Dale Bumpers Small Family Farm Research Center at Booneville, Ark. Male lambs were surgically castrated shortly after birth. All lambs were weaned in July at approximately 90 d of age and transported (360 km) to the USDA-ARS Grazinglands Research Laboratory, El Reno, Okla. Prior to entering the feedlot, lambs were individually weighed, treated for internal parasites and vaccinated for *Clostridium perfringens* type C and D. Lambs were randomly assigned within genotype to one of two pens. In year 1, the number of SxS lambs was limited and only one pen was used. A total of 9 pens were used in year 1 and 10 pens were used in year 2. Each pen was 5.5 m x 21.5 m and the surface was concrete. A roof covered 35 percent of the pen, including a self-feeder that was 2.4 m in length. Lambs had ad libitum access to the feed in the self-feeder and to water provided by a fountain in each pen. Initially, a starter diet (Table 1) was fed. The proportion of alfalfa hay in the starter diet was decreased, and the proportion of corn in the starter diet was increased by 5 percentage units at 5-d intervals until alfalfa hay content was < 16 percent (Table 1).

Lambs were individually weighed at the beginning and end of the feeding period after a 16-h fast without feed and water. Lambs were considered finished when the mean final body weight of the pen was 50 kg or greater. Lambs were fed for 114 d (Year 1) or 105 d (Year 2). At the end of the feeding period, one lamb with a body weight equal to the average body weight of that pen was chosen for detailed carcass evaluation. Selected lambs were transported (130 km) to the Oklahoma State University, Stillwater, Okla. to determine cold-carcass weight and weight of wholesale cuts (leg, loin, shoulder and rack).

Data were analyzed using the PROC MIXED procedure of SAS (1999). The model contained year, genotype and year x genotype. Pen was used as the experimental unit and was considered to be random. Orthogonal contrasts were conducted to test the following effects; 1) purebred St. Croix lambs (SS) vs all other lambs, 2) Romanov sired lambs (RP and RS) vs Texel sired lambs (TP and TS), and 3) lambs from Polypay

Table 1. Composition of starter and finishing diets used in Experiments 1 and 2.

	Diet	
Ingredient	**Starter diet**	**Finishing diet**
Ingredient composition	%	
Alfalfa hay	40.7	15.4
Corn	50.8	77.0
Soybean meal	2.0	0.7
Molasses	5.0	5.0
Limestone	0.9	1.2
Salt	0.5	0.5
Dicalcium phosphate	0.1	
Nutrient composition[a]		
Crude protein, %	13.2	10.9
NE_m, Mcal/kg	1.71	1.95
NE_g, Mcal/kg	1.07	1.27
Ca, %	1.4	1.2
P, %	0.3	0.3

[a] Nutrient composition was calculated from feed composition values in NRC, 1985 and as expressed on a dry matter basis.

ewes (RP and TP) vs lambs from St. Croix ewes (RS and TS). Carcass and cutout data were analyzed using the same model and contrasts, but *animal* was used as the experimental unit. Means are reported as least squares means.

Experiment 2:

A total of 251 ewe and wether lambs were used to determine the impact of sire breed and ewe genotype on feedlot performance and carcass characteristics. Female lambs generated during Exp. 1 were retained at the USDA-ARS Dale Bumpers Small Family Farm Research Laboratory and used to create a flock of ewes of five different genotypes (RxP, RxS, SxS, TxP and TxS). Ewes were bred to either Dorset or St. Croix rams in the fall of 1994 and Dorset rams in the fall of 1995. Lambs were born in the spring of the subsequent year, were managed as described in Exp. 1 and shipped to El Reno, Okla. on August 1, 1995 (n=128) and July 9, 1996 (n=123). Lambs were processed and fed in the same pens as described in Exp. 1. Lambs were grouped by ewe genotype (n =5) and sex (n=2) then each group was randomly assigned to one of ten pens. In 1995, Dorset- and St. Croix-sired lambs were fed in the same pen. Lambs were fed the same diets and body weights were collected as described in Exp. 1. In 1995, a total of 10 Dorset-sired lambs were selected (two lambs from each pen of wether lambs) to determine cold-carcass weight, weight of wholesale cuts (leg, loin, shoulder and rack) and carcass characteristics. Lambs were selected based on a body weight close to the average body weight for the Dorset-sired lambs in that pen.

Initially, feedlot performance was analyzed within each year using *lambs* as the experimental unit. Data collected in 1995 was analyzed with a model containing sire breed, ewe genotype, sex of lamb, and all two and three way interactions. The residual was used as the error term. Sire breed was dropped from the model used to analyze the data collected in 1996 (only one sire breed was used). Data from both years were analyzed using PROC MIXED procedure of SAS (1999) using *pen* as the experimental unit. The model contained sex of lamb, ewe genotype and sex of lamb x ewe genotype interaction. Year was considered random and orthogonal contrasts were conducted to test the following effects; 1) lambs from purebred St. Croix ewes vs all other lambs, 2) lambs from Romanov-sired ewes (RxP and RxS) vs lambs from Texel-sired ewes (TxP and TxS), and 3) lambs from crossbred Polypay ewes (RxP and TxP) vs lambs from crossbred St. Croix ewes (RxS and TxS), and 4) the interaction of sire breed and crossbred ewes (RxP and TxS vs RxS and TxP). Means are reported as least squares means.

Results and Discussion

Experiment 1

In Exp. 1, lambs were fed for 114 d in 1993 (August 8 to November 30) and for 105 d in 1994 (July 12 to October 25). Lambs used in year 2 were heavier ($P < 0.01$) at the beginning of the experiment than the lambs used in year 1, (27.6 vs. 23.0 kg, respectively), but ADG (213 g) was not different ($P = 0.29$) between years. As a result lambs reached the target finished body weight of 50 kg sooner in year 2 than in year 1.

No significant ($P > 0.10$) genotype x year interaction was observed for feedlot performance or carcass measurements. Data was then analyzed by PROC MIXED procedure (SAS, 1999) using a model containing genotype. Year and pen (year) were considered random. The same orthogonal contrasts as previously described were used with this new model. Data are presented as least squares means (Table 2). Purebred St. Croix lambs were lighter ($P < 0.01$) at the beginning and end of the finishing period as compared to all other lambs. A final body weight (BW) of 50 kg was reached by all genotypes with the exception of the purebred St. Croix. At the observed ADG, purebred St. Croix lambs would have needed an additional 43 d to reach a BW of 50 kg. Purebred St.Croix lambs had lower ADG ($P < 0.01$) and lower gain:feed ($P < 0.05$) ratio lambs than the other four genotypes. Because initial BW was different between the purebred St. Croix lambs and the other lambs, initial BW was used as a co-variant in an additional analysis. Initial BW was not a significant ($P > 0.10$) factor affecting final BW or ADG.

Average daily gains ($P = 0.79$) and final BW ($P = 0.59$) were similar among

Table 2. Least squares means for feedlot performance and carcass cutability of wether lambs sired by Romanov (R), St. Croix (S) or Texel (T) rams from Polypay (P) or St. Croix (S) ewes (Exp. 1).

	RP	RS	SS	TP	TS	SE
Feedlot performance[a]						
Number of pens	4	4	4	4	4	
Initial BW, kg[bd]	26.2	25.2	20.4	27.1	24.9	1.5
Final BW, kg[bd]	51.0	48.7	39.6	51.3	49.6	2.5
ADG, g[b]	225	216	180	220	226	7.0
Feed intake, kg/d	1.42	1.35	1.36	1.43	1.45	0.08
Gain:Feed[b]	0.160	0.159	0.133	0.156	0.157	0.011
Carcass cutability						
Number of lambs	4	4	4	4	4	
Final BW, kg[b]	50.8	49.9	41.8	50.8	50.8	0.8
Cold carcass wt, kg[b]	23.8	23.9	20.9	23.8	24.7	2.0
Leg, kg	7.08	7.26	6.08	7.22	7.54	0.77
Loin, kg	2.44	2.57	2.17	2.79	2.49	0.18
Rack, kg[b]	2.56	2.77	2.33	2.70	2.52	0.12
Shoulder, kg[b]	5.31	5.11	4.54	6.17	5.63	0.31

[a] Feedlot performance was calculated using pen data.
[b] Contrast of purebred SS lambs vs all other genotypes, $P < 0.05$.
[c] Contrast of lambs sired by Romanov rams (RP and RS) vs lambs sired by Texel rams (TP and TS), $P < 0.05$.
[d] Contrast of lambs from Polypay ewes (RP and TP) vs lambs from St. Croix ewes (RS and TS), $P < 0.05$.

Romanov- and Texel-sired lambs. Lambs from Polypay ewes were heavier (P < 0.05) at the beginning (26.6 vs. 25.0 kg) and end (51.2 vs. 49.2 kg) of the experiment than lambs from St. Croix ewes. Daily feed intake was similar (P = 0.87) among the five genotypes, but feed efficiency (Gain: Feed) was different (P < 0.05) reflecting the differences in ADG.

Hair sheep are smaller and weigh less than wool sheep (Notter et al., 2003; Shelton, 1991). Lambs with small frame size, such as hair sheep, can be fed to heavier body weights to yield heavier carcasses, but the additional weight gain is predominately fat (Nichols et al., 1993). In this experiment, feeding purebred St. Croix lambs to heavier final body weights would only increase carcass fat and further depress feed efficiency. Snowder et al. (1994) established an optimal slaughter weight of 45 to 47 kg for Polypay wethers to yield a carcass with a quality grade of Choice and a Yield Grade between 2 and 3. However, with current industry slaughter weights of > 60 kg, Yield Grades would no doubt be much higher if these lambs were fed to heavier carcass weights.

Carcass measurements shown in Table 2 were recorded on four wether lambs of each genotype. The number of observations for each genotype is small and the data should be considered preliminary. Differences in cold-carcass weight are a reflection of differences in final BW. Purebred St. Croix lambs had lower (P < 0.05) cold carcass, leg, rack and shoulder weights than those observed for the other four genotypes. Lambs sired by Texel rams had greater amounts (P < 0.05) of shoulder than lambs sired by Romanov rams, reflecting differences in carcass conformation. However with the exception of Texel-sired lambs vs. Romoanov-sired lambs, when wholesale cuts are expressed as a percentage of the cold carcass weight none of the contrasts were significant (P > 0.15). The Texel-sired lambs yielded more shoulder (P < 0.05) as a percentage of the cold- carcass weight than Romanov-sired lambs (25 percent vs. 22 percent, respectively). Overall the percentage of leg, loin, rack and shoulder was 30.1 percent, 10.9 percent, 11.2 percent and 23.2 percent, respectively.

Table 3. Least squares means for feedlot performance of female (F) and wether (W) lambs sired by Dorset or St. Croix rams from Romanov x Polypay (RxP), Romanov x St. Croix (RxS), St. Croix x St. Croix (SS), Texel x Polypay (TxP), Texel x St. Croix (TxS) ewes (Exp.2).

Item	Sex	N	Initial BW	Final BW	ADG
Year 1					
Dorset sired	F	29	19.3 kg	49.3^{b} kg	208^{b} g
	W	32	21.6 kg	53.3^{a} kg	268^{a} g
St. Croix sired	F	37	18.3 kg	44.1^{b} kg	168^{c} g
	W	30	18.9 kg	43.4^{b} kg	194^{b} g
SE			0.7 kg	1.3 kg	6.5 g
Year 2					
Dorset sired	F	69	24.9 kg	45.9^{a} kg	155^{a} g
	W	54	25.3 kg	50.2^{b} kg	185^{b} g
SE			0.5 kg	0.9 kg	3.7 g

^{abc} Means in the same year and column with different superscripts are different P < 0.01.

Experiment 2

In Exp. 2, lambs used in Year 1 (1995) were sired by either Dorset or St. Croix rams and lambs used in Year 2 (1996) were sired by Dorset rams (Table 3). Among ewe and wether lambs fed in Year 1, Dorset-sired lambs had greater ADG (239 g vs 179 g; P < 0.01) and were heavier (51.4 kg vs 43.5 kg; P < 0.01) at the end of the finishing period than lambs sired by St. Croix rams. There was a sex-of-lamb x breed-of-sire interaction for lambs fed in Year 1 for final body weight (P < 0.10) and ADG (P < 0.01). Differences in final body weight and ADG were greater between ewe and wether lambs sired by Dorset rams than between ewe and wether lambs sired by St. Croix rams (Table 3).

In general, female lambs weighed less (P = 0.11) at the beginning of the feeding period, had lower ADG (P < 0.01), and consumed less feed (P = 0.14)

Table 4. Least squares means for feedlot performance of lambs sired by Dorset and St. Croix rams from Romanov x Polypay (RxP), Romanov x St. Croix (RxS), St. Croix x St. Croix (SS), Texel x Polypay (TxP), Texel x St. Croix (TxS) ewes (Exp. 2).

	Ewe genotype					
	RP	RS	SS	TP	TS	SE
Feedlot performance						
Number of pens	4	4	4	4	4	
Initial BW, kg^{bd}	22.1	20.4	21.3	24.9	23.8	2.6
Final BW, kg^{abcd}	48.2	45.4	44.7	52.6	50.9	1.04
ADG, g^{d}	202	181	169	222	198	23
Feed intake, kg/d^{c}	1.43	1.18	1.23	1.52	1.34	0.07
Gain:Feed	0.147	0.147	0.135	0.151	0.149	.008

[a] Contrast of lambs from purebred St. Croix ewes vs lambs from crossbred ewes, P<0.05

[b] Contrast of lambs from ewes sired by Romanov rams (RP and RS) vs lambs from ewes sired by Texel rams (TS and TP), P<0.05.

[c] Contrast of lambs from ewes with Polypay breeding (RP and TP) vs lambs from ewes with St. Croix breeding (RS and TS), P<0.05.

[d] Contrast of lambs from SS and RS ewes vs lambs from RP, TP and TS ewes, P < 0.01.

Table 5. Least squares means for carcass cutability of wether lambs sired by Dorset rams bred to Romanov x Polypay (RxP), Romanov x St. Croix (RxS), St. Croix x St. Croix (SS), Texel x Polypay (TxP), Texel x St. Croix (TxS) ewes (Exp. 2).

	Ewe genotype					
	RP	RS	SS	TP	TS	SE
Number of lambs	2	2	2	2	2	
Final BW, kg[bc]	54.2	47.9	51.3	53.1	53.6	1.5
Cold carcass wt, kg	28.1	25.1	28.3	27.9	28.6	1.4
Wholesale cuts						
Leg, kg[ac]	7.22	6.27	7.17	7.35	7.76	0.29
Loin, kg[c]	2.42	2.04	2.23	2.25	2.38	0.40
Rack, kg	2.77	2.62	2.60	2.46	2.58	0.09
Shoulder, kg[ac]	5.31	4.30	5.06	5.23	5.58	0.21

[a] Contrast of lambs from ewes sired by Romanov rams (RP and RS) vs lambs from ewes sired by Texel rams (TS and TP), P<0.05.
[b] Contrast of lambs from ewes with Polypay breeding (RP and TP) vs lambs from ewes with St. Croix breeding (RS and TS), P<0.10.
[c] Contrast of lambs from RP and TS ewes vs RS and TP ewes, P<0.10

than wether lambs. We concluded that female lambs grow at a slower rate and are less efficient than male lambs. Notter et al. (2003) and Phillips et al. (2002) reported similar observations made on wether and female lambs from hair and black-faced sheep. We also concluded that Dorset-sired lambs gain weight more rapidly than St. Croix-sired lambs.

In Exp. 2, the breed-of-sire x ewe-genotype interaction in Year 1 was not significant (P > 0.38). Therefore, sire breed was dropped from the model. Using pen as the experimental unit, data were analyzed to determine the impact of ewe genotype on feedlot performance (Table 4). Lambs from purebred St. Croix ewes gained weight at a slower rate (P < 0.05) and were lighter (P>0.01) at the end of the finishing period than lambs from crossbred ewes. Lambs from Texel-sired ewes (TP and TS) had heavier (P < 0.01) initial and final BW as compared to lambs from Romanov-sired ewes (RP and RS). Also, ADG tended to be greater (P = 0.12). Lambs from Polypay crossbred (RP and TP) ewes had heavier (P<0.10) initial BW and final BW and greater ADG than lambs from St. Croix crossbred ewes (RS and TS). In this experiment, feed intake followed the same pattern as ADG. Lambs that consumed more feed had higher ADG. As a result, Gain:Feed was not different (P > 0.70) among lambs from the five ewe genotypes used in this study.

In the present experiments, feedlot performance was similar to previous reports from this laboratory using comparable diets and the same feeding facilities (Phillips 1990 and 1993; Phillips and VonTungeln, 1991). In previous experiments, ADG ranged from 185 to 280 g, daily feed intake ranged from 1.06 to 1.72 kg, and Gain:Feed from 0.108 to 0.180.

In Exp 2, carcass-cutout data was collected only during year 1 and only from Dorset-sired lambs (Table 5). The number of observations for each ewe genotype is small and the data should be considered preliminary. Lambs from purebred St. Croix ewes produced as much cold carcass weight and wholesale cuts as lambs from crossbred ewes. Lambs from Texel sired ewes (TP and TS) produced heavier (P < 0.05) leg and shoulder wholesale cuts than lambs from Romanov sired (RP and RS) ewes. Using a Dorset rams to sire lambs from purebred St. Croix ewes mitigated the negative effects of a hair sheep breed on carcass cutability.

The amount of leg, loin, rack and shoulder harvested from lambs in Exp. 2 was similar to that reported in Exp. 1 (Table 5). Because the number of observations per genotype are small (n=2), data was averaged across genotype and presented as descriptive statistics for each experiment (Table 6). Lambs used in both experiments yielded carcasses that had a quality grade of choice or better. Yield Grades were greater than 3 but less than 4 and fat thickness averaged 0.67 cm. Based on these observations, we concluded that the lambs were fed long enough to produce carcasses that would have a quality grade ≥ Choice and have a Yield Grade ≥ 3.

The amount of longissimus muscle produced in Exp. 1 and Exp. 2 was 12.4 cm^2 and 14.5 cm^2, respectively. The amount of longissimus muscle is proportional to carcass weight. Snowder et al. (1994) reported longissimus muscle area of 12.3 cm^2 or 0.445 cm^2/kg of carcass from purebred Polypay lambs. In Exp. 1 and 2 longissimus muscle per kg of carcass was 0.454 and 0.474, respectively. These observations are less than values of 0.577 cm^2/kg of carcass reported by Neary, et al. (1995) and 0.526 cm^2/kg reported by Shelton (1991). In small-framed lambs, extending the feeding period to produce a heavier carcass increases the amount of carcass fat and will decrease the amount of muscle/kg of carcass (Nichols et al., 1993).

Table 6. Carcass characteristics (mean ± SE) of crossbred wether lambs from Exp. 1 (1994 only) and 2 (1995 only).

	Experiment 1	Experiment 2
Final BW, kg	46.3 ± 0.09	52.2 ± 0.6
Cold carcass wt, kg	24.9 ± 0.4	27.6 ± 0.6
Dressing percent, %	59.1 ± 0.9	58.6 ± 0.9
Quality grade[a]	12.7 ± 0.3	12.7 ± 0.2
Fat thickness, cm	0.71 ± 0.1	0.64 ± 0.04
Longissimus muscle, cm^2	12.4 ± 0.4	14.5 ± 0.7
Yield grade	3.4 ± 0.1	3.2 ± 0.2

[a] Choice – = 11, Choice = 12 and Choice + = 13.

Implications

Cross breeding programs used to produce F1 females also produce F1 males that are finished in feedlots using high-energy diets. From these data, we concluded that crossbred-wether lambs produced from mating Texel, Romanov, St. Croix and Polypay breeds could be efficiently finished under conventional confinement feeding of a high-energy diet. However, purebred St. Croix lambs were smaller and grew slower than crossbred lambs. Wether lambs are more efficient and grow at a faster rate than female lambs. The differential between male and female lambs was greater when Dorset rams were used as the terminal sire. Lambs from ewes with St. Croix breeding performed as well as lambs from ewes with Polypay breeding. Lambs from ewes with Texel breeding were heavier at the start and end of the finishing period. In terms of growth and feed efficiency, Dorset rams were a better terminal sire than St. Croix rams. When Dorset rams were used as the terminal sire, lamb feedlot performance was similar among the different ewe genotypes used in this experiment.

Literature Cited

Bunch, T.D., R.C. Evans, S. Wang, C.P. Brennand, D.R. Whitter, and B.J. Taylor. 2004. Feed efficiency, growth rate, carcass evaluation. Cholesterol level and sensory evaluation of lambs of various hair and wool sheep and their crosses. Small Rumin. Res 52:239-245.

Burke, J.M. and J. E. Miller. 2004. Relative resistance to gastrointestinal nematode parasites in Dorper, Katahdin, and St. Croix lambs under conditions encountered in southeastern region of the United States. Small Rum. Res. 54:43-51.

Freking, B.A., K.A. Leymaster, and L.D. Young. 2000. Evaluation of Dorset, Finnsheep, Romanov, Texel, Montadale breeds of sheep: I. Effect of ram breed on productivity of ewes of two crossbred populations. J. Anim. Sci. 78:1422-1429.

Lewis, R.M., D.R. Notter, D.E. Hogue, and B.H. Magee. 1996. Ewe fertility in the STAR accelerated lambing system. J. Anim. Sci. 74:1511-1522.

Leymaster, K.A. and T.G. Jenkins. 1993. Comparison of Texel- and Suffolk-sired crossbred lambs for survival, growth, and compositional traits. J. Anim. Sci. 71:859-869.

Neary, M.K., M.J. Cecava, and E. P. Berg. 1995. Effect of fishmeal on growth and carcass traits of finishing lambs. Sheep and Goat Res. J. 11:106-110.

Nichols, M.E., H.G. Dolezal, G.Q. Fitch, and W.A. Phillips. 1993. Feedlot performance and carcass characteristics for small, medium, and large framed wethers backgrounded on wheat pasture. Sheep Res. J. 9:82-85.

Notter, D.R. 2000. Effects of ewe age and season of lambing on prolificacy in US Targhee, Suffolk, and Polypay sheep. Small Rumin. Res. 38:1-7.

Notter, D.R., S.A. Andrew, and A.M. Zajac. 2003. Responses of hair and wool sheep to a single fixed dose of infective larvae of *Haemonchus contortus*. Small Rumin. Res. 47:221-225.

Phillips,W.A. 1990. The effect of additional dietary zinc on feeder lamb performance. SID Sheep Res. J. 6:18-23.

Phillips,W.A. 1993. Feedlot performance of feeder lambs fed diets containing different proportions of wheat, corn, and sorghum. Sheep Res. J. 9:71-75.

Phillips,W.A., R.R. Reuter, M.A. Brown, J.Q. Fitch, S.R. Rao, and H. Mayeux. 2002. Growth and performance of lambs fed a finishing diet containing either Alfalfa or Kenaf as the roughage source. Small Rumin. Res. 46:75-79.

Phillips,W.A. and D.L. VonTungeln. 1991. Feedlot performance of lambs fed lactic acid-producing bacteria. Prof. Anim. Sci. 7:19-23.

SAS. 1999. SAS/SAT. Users Guide (Release 7.0) SAS Inst. Cary , NC.

Schroeder, T.C., R.J. Jerrick, R. Jones, and C.S. Spaeth. 2001. U.S. lamb demand. Sheep and Goat Res J. 17:14-19.

Shelton, M. 1991. Hair sheep production under temperate and tropical conditions. In: Hair Sheep Research: Proceeding of Symposium June 28, 1991. St. Croix, U.S. Virgin Islands.

Snowder, G.D., H.A. Glimp, and R.A. Field. 1994. Carcass characteristics and optimal slaughter weights in four breeds of sheep. J. Anim. Sci. 72:932-937.